TWO-PHOTON PHYSICS AT LEP *

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Abstract

A remarkable number of studies have been performed at LEP in the field of two-photon physics in the last four years. These results represent a very important contribution to the understanding of strong interactions at low energies. In particular, significant deviations from QCD predictions are found in the cross sections of inclusive single particle, jet and beauty production. A concise review of some of these results is presented.

1 Introduction

Despite the fact that the LEP collider and the four detectors ALEPH, DELPHI, OPAL and L3 were not conceived and constructed to study two-photon interactions, a very remarkable number of results have been recently obtained by the four LEP collaborations, leading to about twenty-five publications on this subject in the last four years [1]. It is important to notice that, at the high energies above the Z pole, photon-photon interactions are characterized by a cross section more than two orders of magnitude larger than the e^+e^- annihilation process. Moreover, a clean separation between the two-photon and annihilation events is possible by using a cut in the visible energy. High energy LEP data are therefore very well suitable for the study of two-photon interactions.

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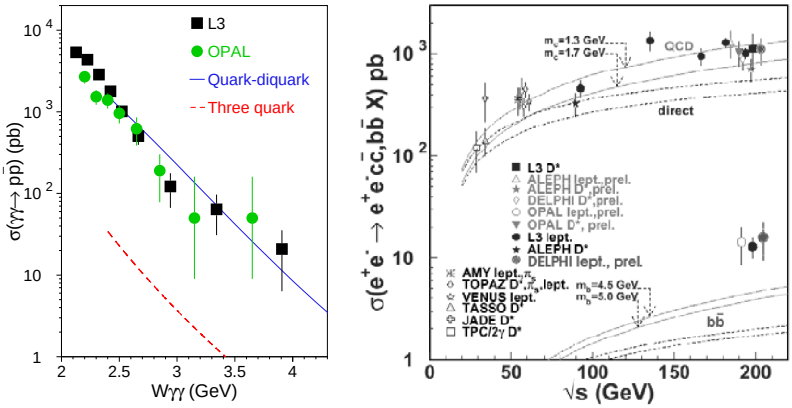

Figure 1: The cross section as a function of the two-photon mass $W_{\gamma\gamma}$ for the process $\gamma\gamma \to p\bar{p}$ (left). The cross section for open charm and beauty production as a function of the e^+e^- mass (right).

2 Exclusive processes

The study of the formation of light resonant states gives fundamental information to light meson spectroscopy and glueball searches. Several resonant states have been studied at LEP and their two-photon widths have been measured with very high accuracy [2]. In particular, the formation of the $f_J(1710)$ has been observed for the first time in gamma-gamma collisions by L3 [3] and the spin-two tensor wave has been found to be dominant in this mass region. No signal has been observed for the $\xi(2230)$ tensor glueball candidate.

Due to the high mass of charm quarks, the formation of charmonia can be used to test perturbative QCD predictions. The two-photon width of the η_c and of the χ_{c2} has been measured by DELPHI [4], L3 [5] [6] and OPAL [7] and an upper limit for the formation of the η_c' has been set by DELPHI [8].

The η_b meson has not been observed so far and its search is very challenging. Considering the very small number of expected events, only a combination of the data from the four LEP experiments would allow the claim of a discovery. Up to present, only one candidate has been observed ALEPH [9] and preliminary results have been presented by L3 [1].

Baryon-antibaryon pair production allows to investigate the structure of baryons which can be described in terms of three-quark or quark-diquark models. The studies of $\Lambda\bar{\Lambda}$ and $\Sigma^0\bar{\Sigma}^0$ by L3 [10] and of $p\bar{p}$ exclusive production by L3 [11] and OPAL [12] clearly show a

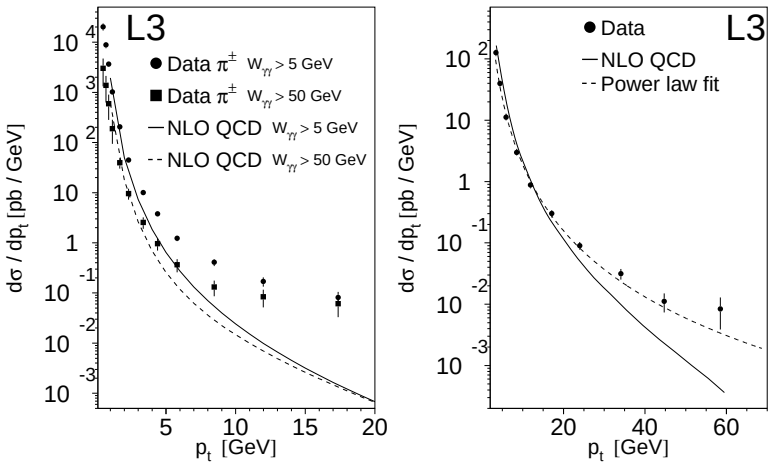

Figure 2: The cross section as a function of the transverse momentum for inclusive charged hadron (left) and jet (right) production.

good agreement with the predictions of the quark-diquark model and exclude the three-quark model, as shown in Figure 1 (left).

3 Inclusive processes

The measurement of open charm production in two-photon collisions has been performed using the lepton tag method by L3 [13] [14] and the D^* tag method by ALEPH [15], L3 [16] and OPAL [17]. As reported in Figure 1 (right), good agreement has been found with perturbative QCD predictions. These results show that only the direct interaction of the photon is not sufficient to describe the data. The contribution to the cross section due to the gluonic content of the photon is about 50%.

The cross section of open beauty production has been measured by L3 [14] and preliminary results have been presented at by OPAL and DELPHI [1]. There is a very good agreement between the three experimental measurements but, as shown in Figure 1 (right), an inconsistency of more than a factor two has been found between data and perturbative QCD predictions. The reason of this inconsistency is unknown and a careful investigation of this problem is mandatory.

The cross section for $\pi^{\pm}$, π^0 and K^0_s inclusive production in the reaction $\gamma\gamma \to$ hadrons has been measured as a function of the transverse momentum and the pseudorapidity by L3 [18] [19] and OPAL [20]. Agreement with respect to QCD predictions is found for all particles at $p_t < 4$ GeV while data are significantly higher than the QCD predic-

tions for $\pi^{\pm}$ and π^0 at high p_t, as shown in Figure 2 (left). The study of the production of jets in two-photon collisions has been performed by L3 [21] and OPAL [22]. As presented in Figure 2 (right), a clear excess of the measured cross section with respect to QCD predictions has been observed at high p_t values in inclusive jet production by L3. Several checks have been performed to investigate possible experimental problems and no effect has been found to be responsible for this discrepancy. A careful theoretical investigation is therefore mandatory. A natural question rises: is there any correlation between these effects at high p_t and the problem of the open beauty production cross section?

4 Conclusions

The LEP collider has given fundamental contributions to two-photon physics. In particular, the high energy data above the Z pole allowed the first observation of open beauty production and the study of high transverse momentum single particle and jet production. For these processes significant deviations from QCD predictions have been observed and no explanation has been found for these effects at present.

References

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